



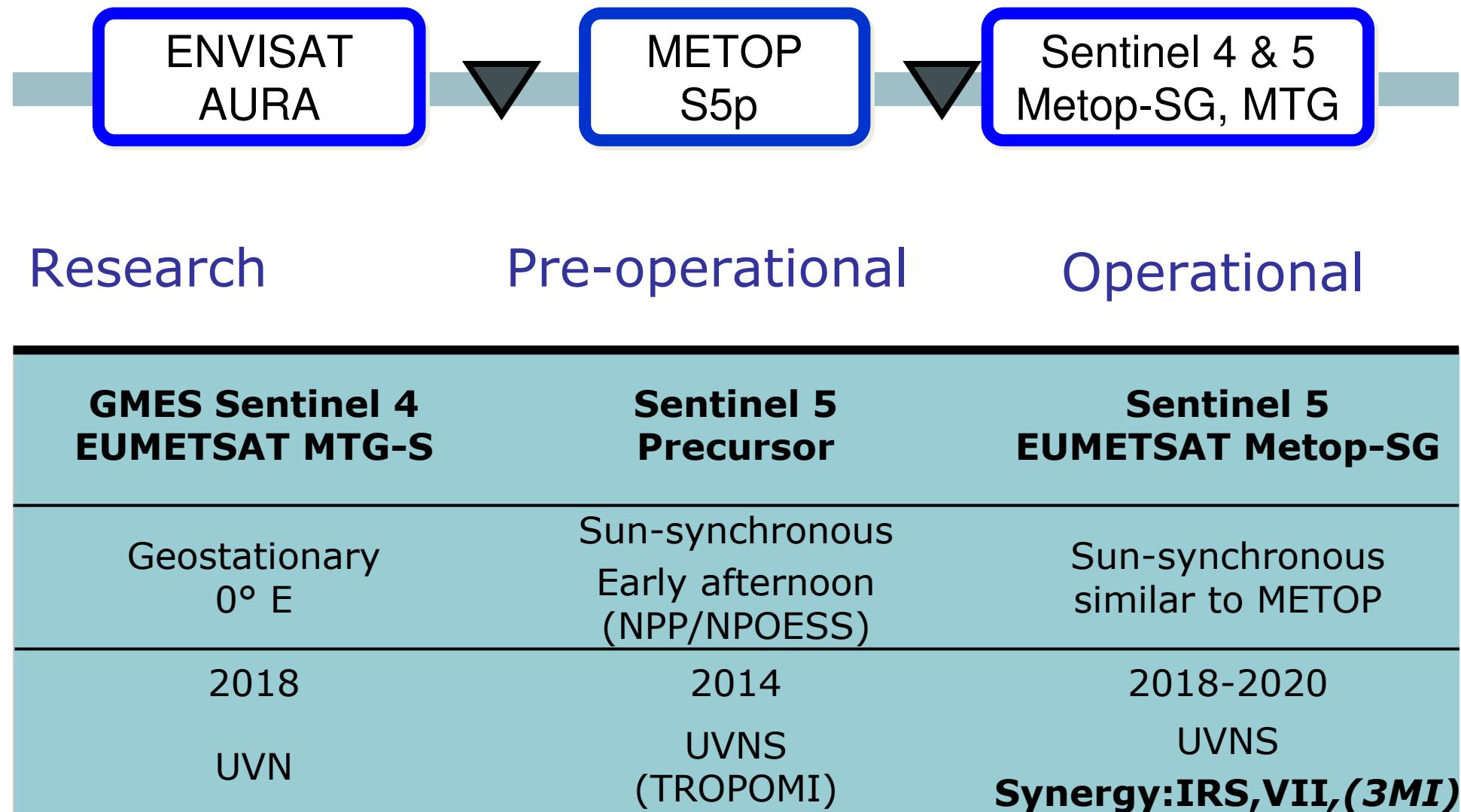
Koninklijk Nederlands  
Meteorologisch Instituut  
Ministerie van Verkeer en Waterstaat

*Contribution of the  
sentinel 4,5 and s5p  
missions for further  
understanding of climate-  
chemistry interaction*

*by P.F. Levelt, J.P.  
Veefkind and M. van  
Weele (KNMI, TUD)*

Pieter Cornelis Levelt (KNMI, TUD), Pepijn  
Veefkind (KNMI, TUD) and Michiel  
van Weele (KNMI)

# European Remote Sensing of Atmospheric Composition : Timeline





# sentinel-5 precursor

GMES ATMOSPHERE MISSION IN POLAR ORBIT

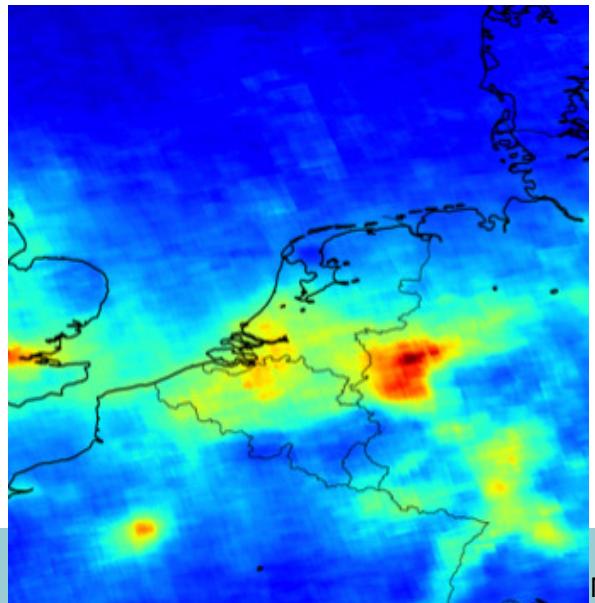
The ESA Sentinel-5 Precursor (S-5P) is a pre-operational mission focussing on global observations of the atmospheric composition for air quality and climate.

The TROPOspheric Monitoring Instrument (TROPOMI) is the payload of the S-5P mission and is jointly developed by The Netherlands and ESA.

The planned launch date for S-5P is 2014 with a 7 year design lifetime.

## TROPOMI

- UV-VIS-NIR-SWIR nadir view grating spectrometer.
- Spectral range: 270-500, 675-775, 2305-2385 nm
- Spectral Resolution: 0.25-1.1 nm
- Spatial Resolution: 7x7km<sup>2</sup>
- Global daily coverage at 13:30 local solar time.



## CONTRIBUTION TO GMES

- Total column O<sub>3</sub>, NO<sub>2</sub>, CO, SO<sub>2</sub>, CH<sub>4</sub>, CH<sub>2</sub>O, H<sub>2</sub>O, BrO
- Tropospheric column O<sub>3</sub>, NO<sub>2</sub>
- O<sub>3</sub> profile
- Aerosol absorbing index, type, optical depth

## Synergy Sentinel 5 with other instruments on Platform A

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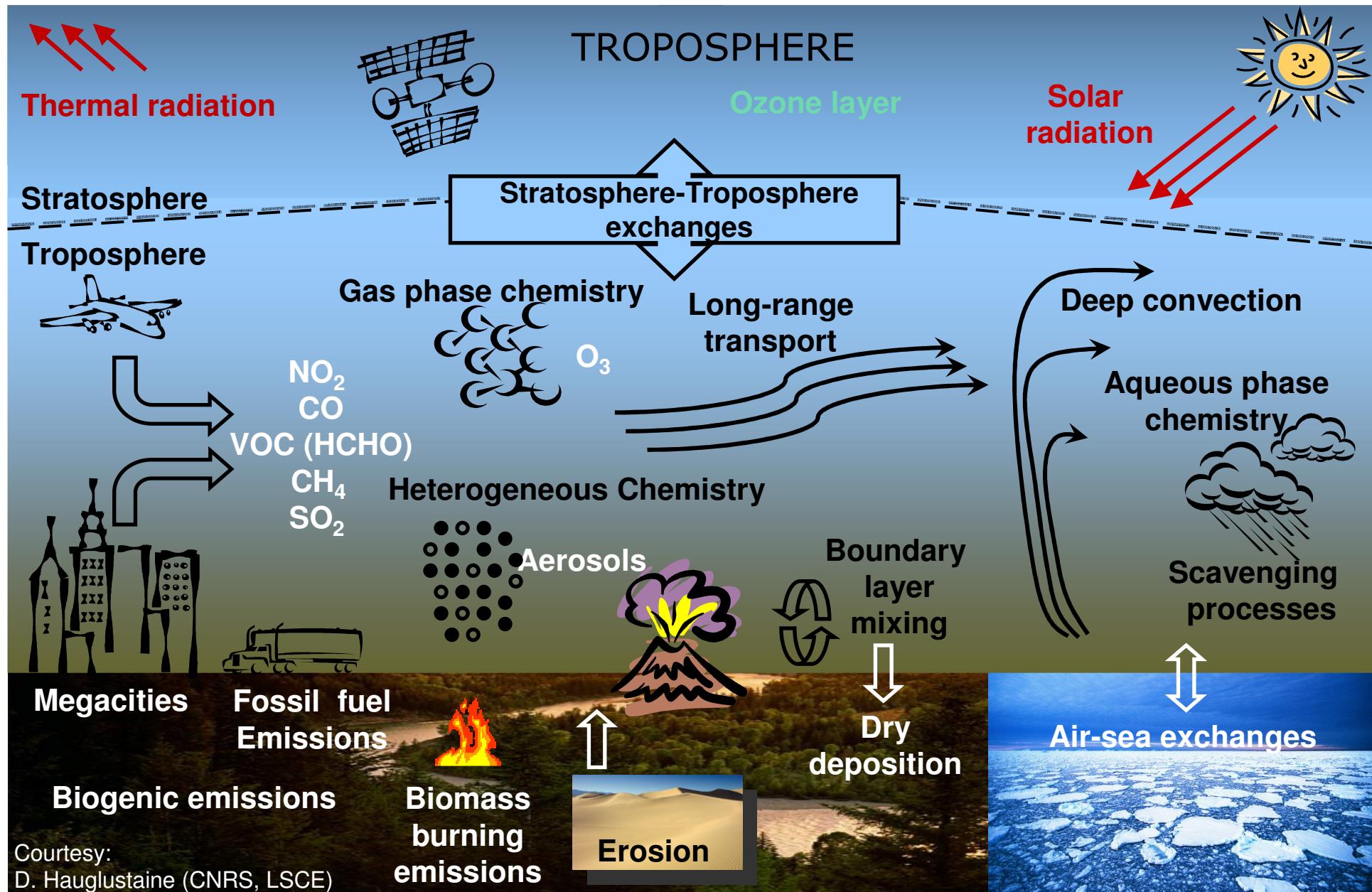
Synergy sentinel 5, IRS, VII and (potentially) 3MI will lead to essential and unprecedented steps forward in:

- *Improved retrievals*
- *Improved monitoring*
- *Improved science*

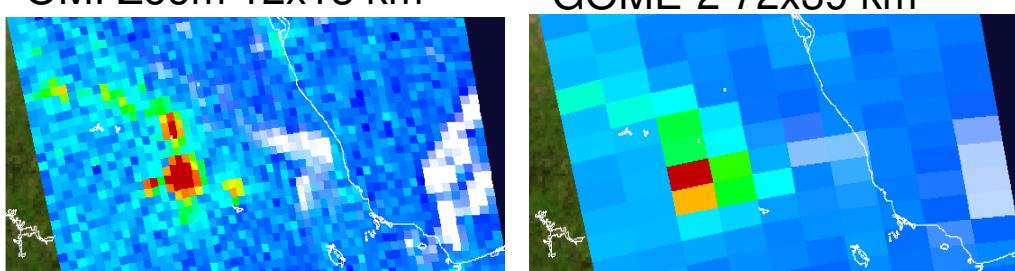
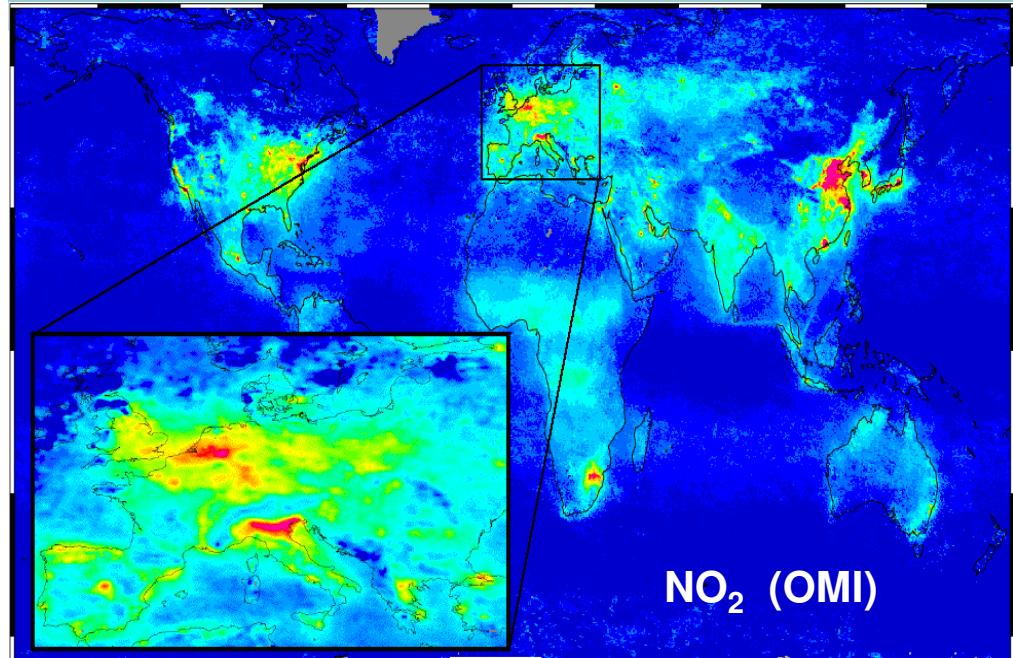
With the focus on the troposphere

ESA CAMELOT and ONTRAQ study focussed on the benefits from synergy obtained with above instruments on 1 platform:

- *Improved tropospheric products using combined retrieval*
- *Improved selection cloud-free measurements and improved cloud correction*
- *Major step forward in understanding chemistry-climate interaction and air quality*



# Challenges in tropospheric observation capabilities



Mexico City, January 20, 2005

Courtesy: J.P. Veefkind (KNMI)

- Horizontal Scales: Global versus urban scales
- Vertical scales: Columns versus profiles
- Time scales: Years, Daily to diurnal resolution
- Several co-located species

*Sentinels s5p, s4 and s5 are going to address the challenges above*

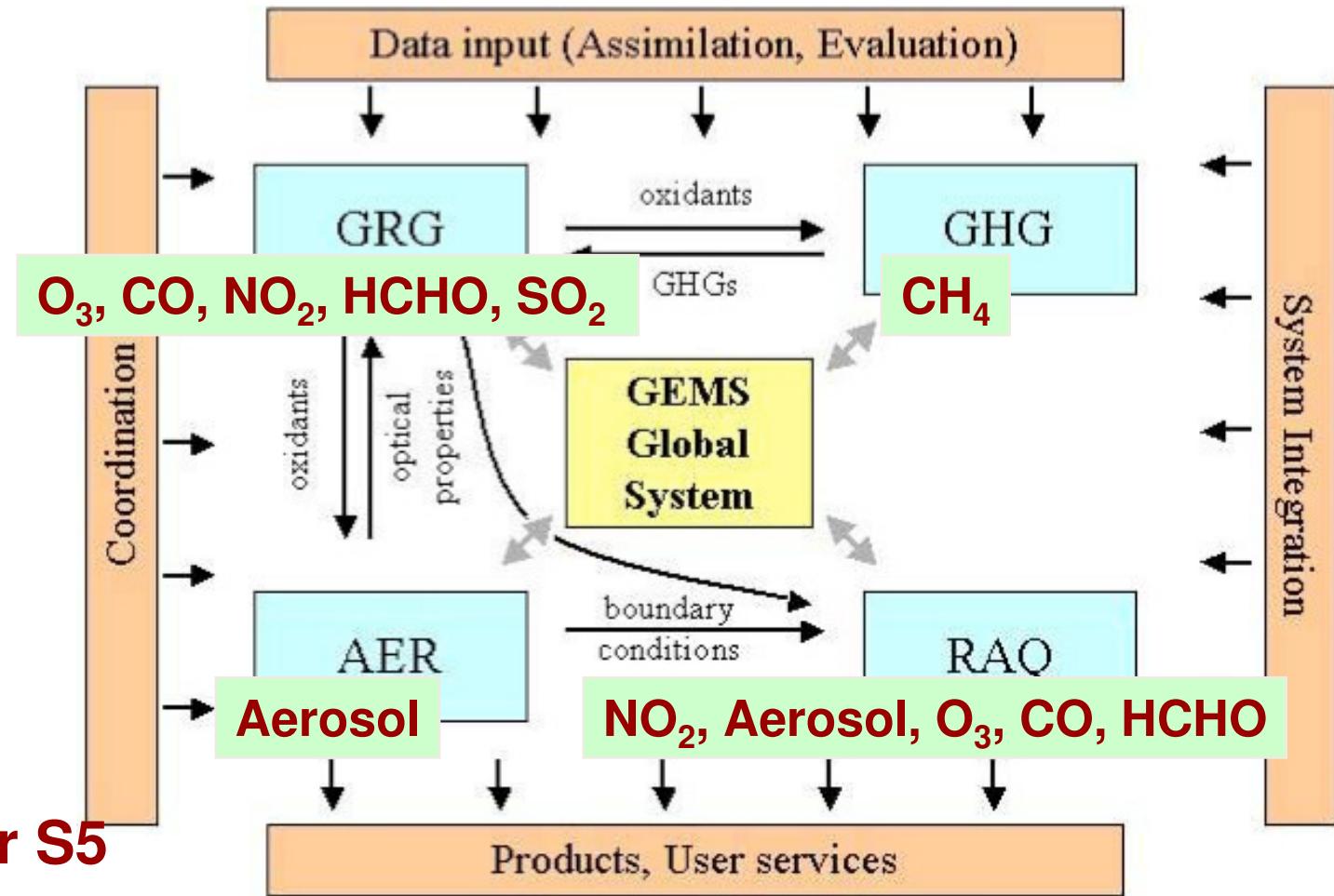
# EU GEMS/MACC Project, coord. by ECMWF

Global & regional Earth-system Monitoring using Satellite and in-situ data  
EU GMES

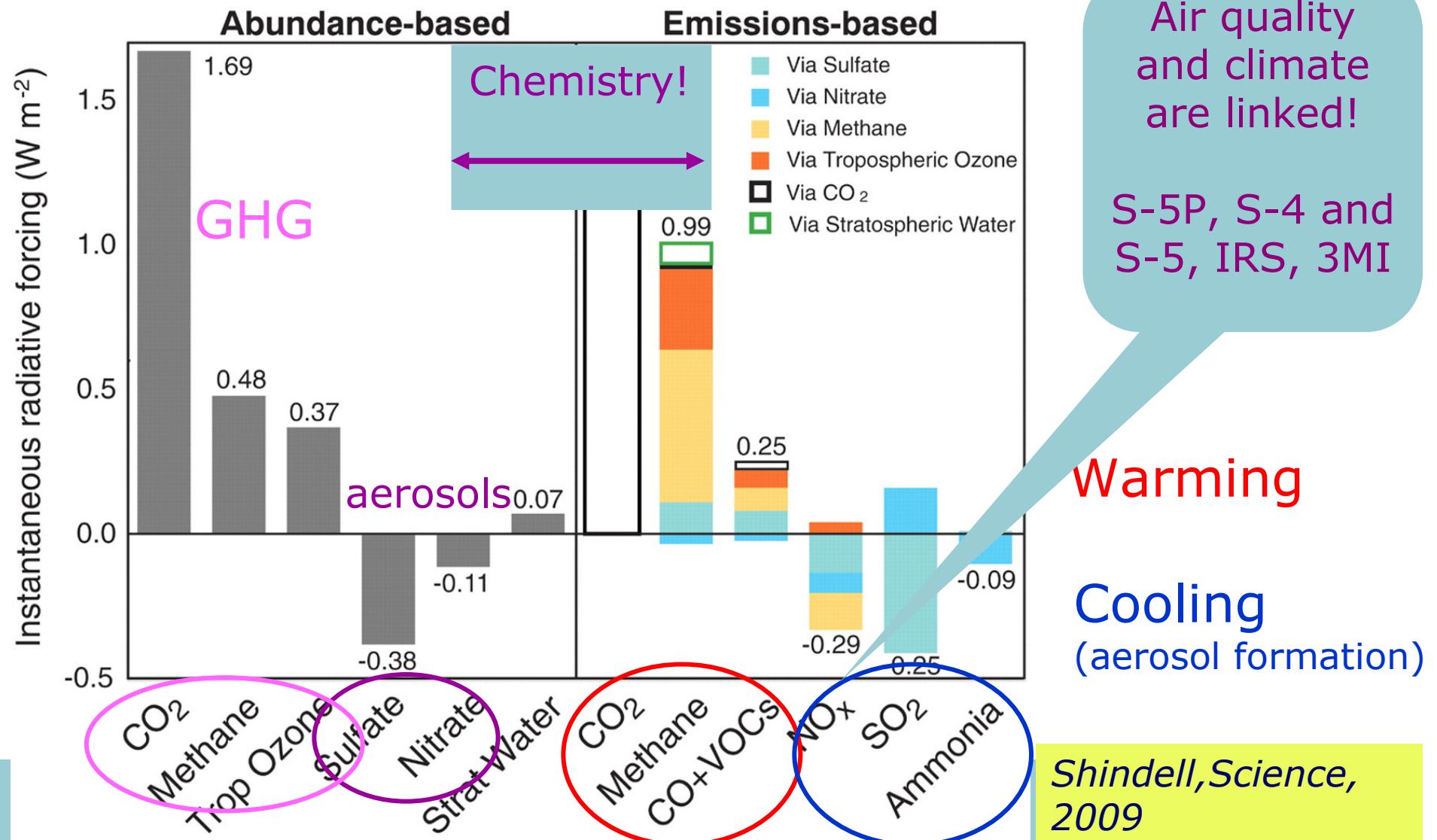
Subprojects:

- Greenhouse gases
- Reactive gases
- Aerosols
- Regional AQ

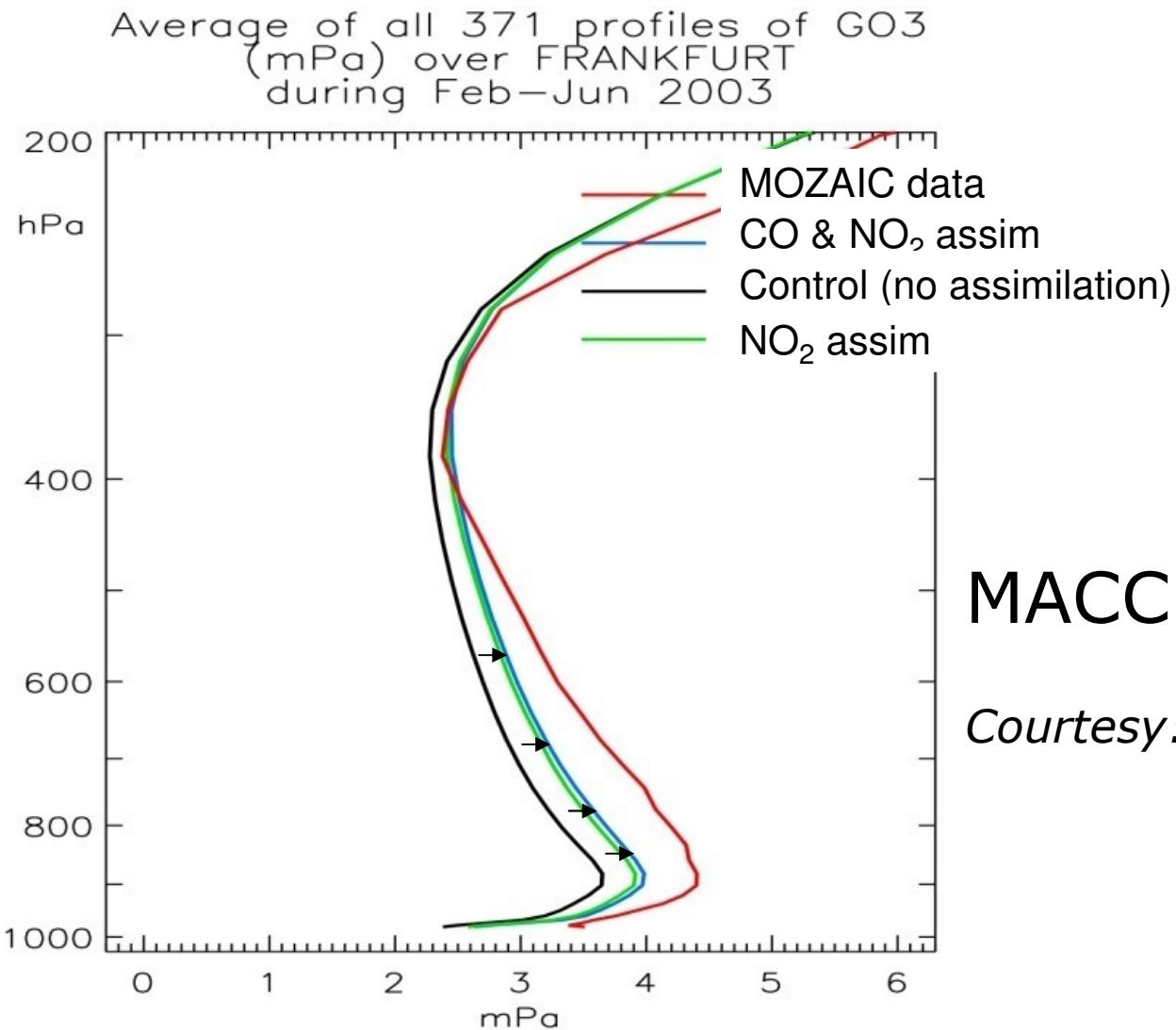
**Sentinel 4/5  
and precursor S5  
Observations**



# Impact of precursors ( $\text{NO}_2$ , $\text{SO}_2$ , $\text{CO}$ ) and non-CO<sub>2</sub> green house gases on climate: Emission based estimates

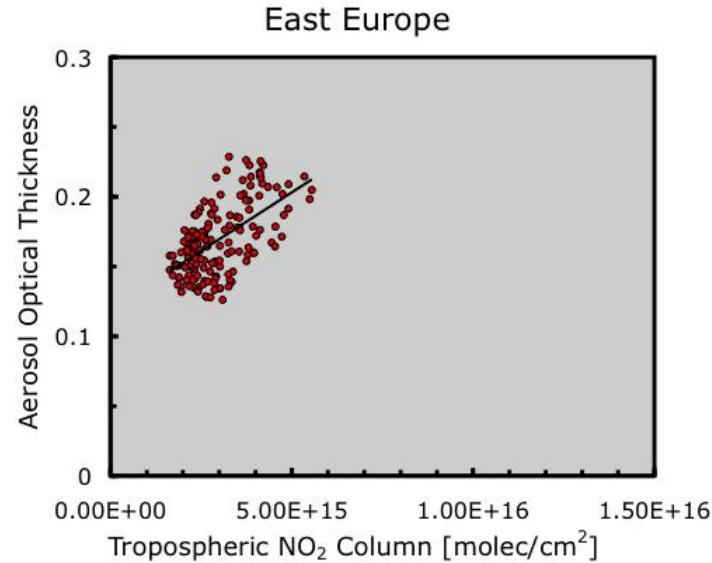
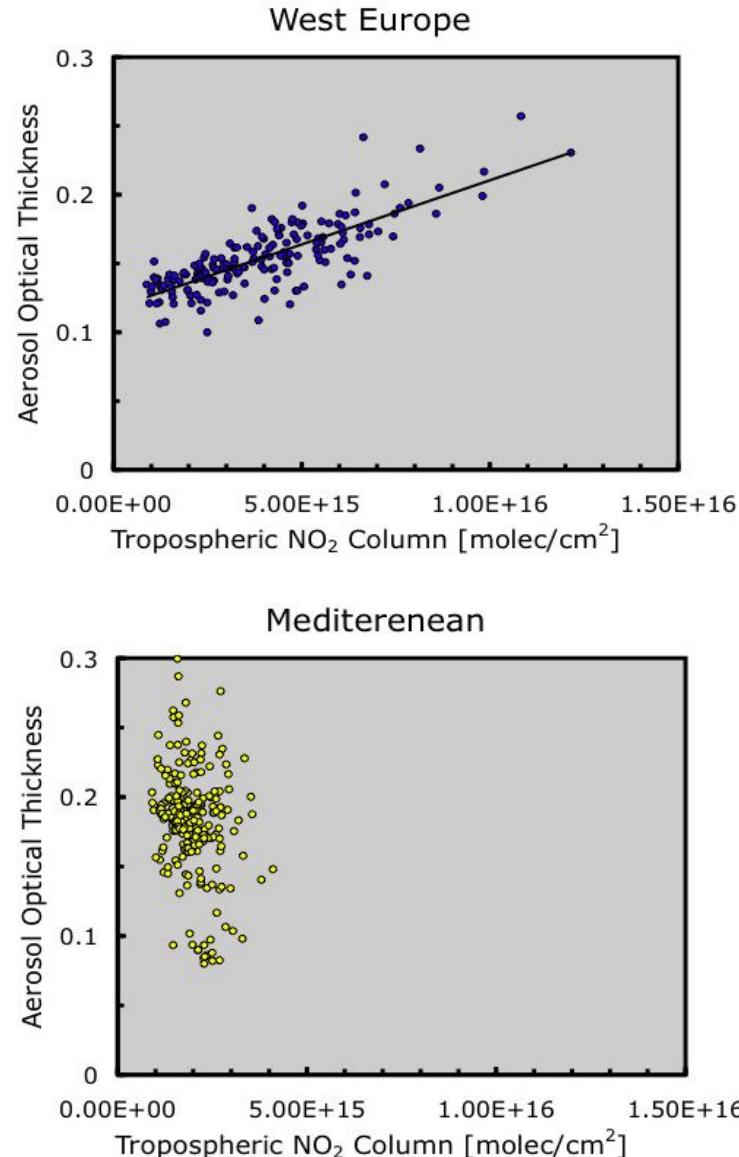


# Active assimilation of $\text{NO}_2$ helps to improve ozone profiles in the troposphere



# AOT - NO<sub>2</sub> Spatial Correlation

## MODIS aerosol and OMI NO<sub>2</sub>



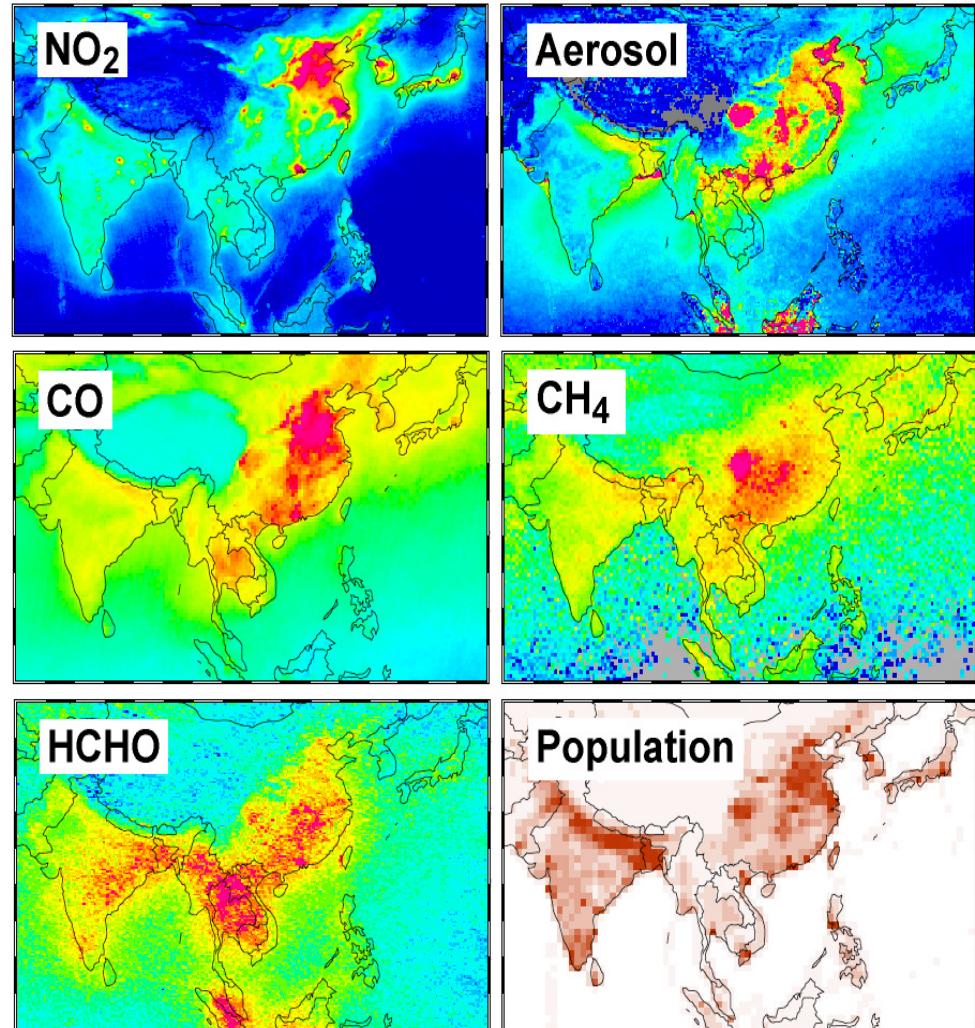
Region	Correlation	Slope
West Europe	0.79	$0.93 \cdot 10^{-17}$
East Europe	0.58	$1.68 \cdot 10^{-17}$
Mediterranean	-0.20	N/a

Veefkind et al, KNMI

# Understanding Atmospheric Chemistry for Air Quality and Climate Change

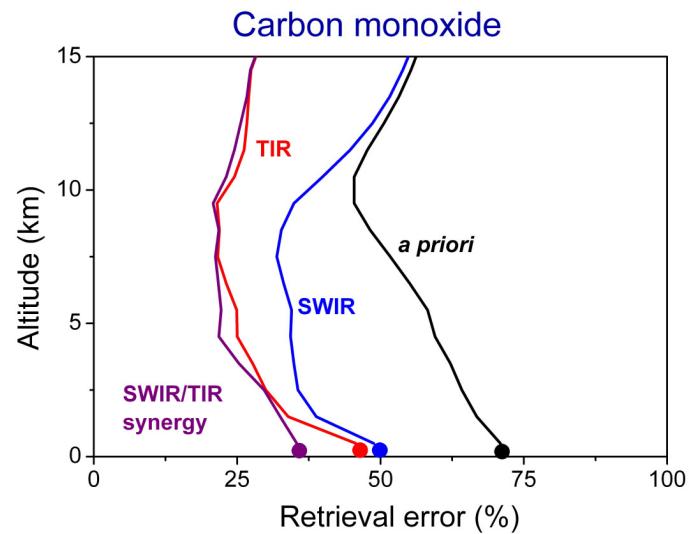
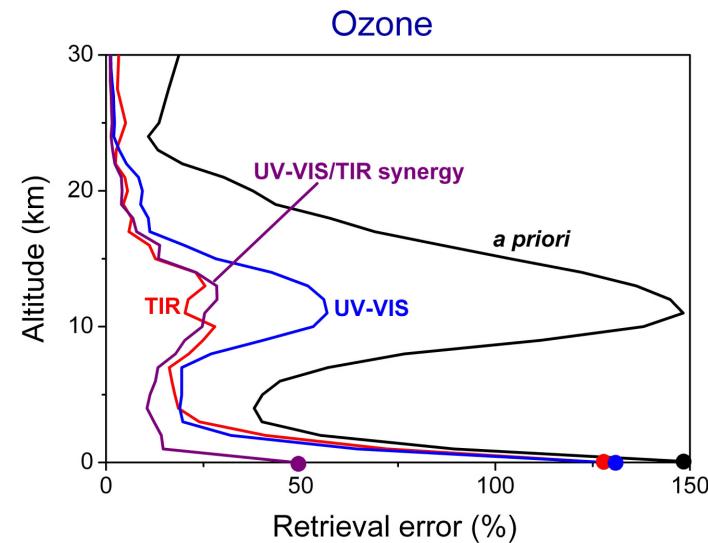
## Analysis based on several co located species

- Need for co-located and co-timed measurements
- Need for improved tropospheric products and emission monitoring (combined retrieval and improved cloud detection)
- Need for consistency in retrieval methods



Courtesy: Eskes, KNMI

# Combined retrieval



Left: UV/VIS and TIR  $O_3$  combined retrieval  
Right: TIR and SWIR CO combined retrieval

Courtesy: P.F. Coheur (ULB)

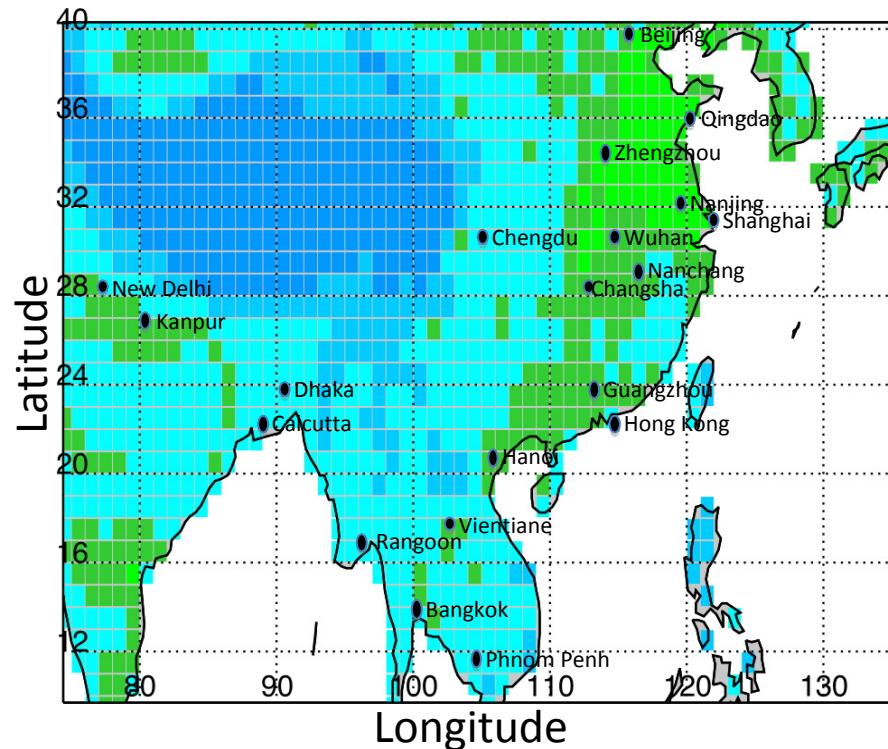
- *Sensitivity to the Pollution Boundary Layer*
- *2 to 3 independent measurements in the troposphere*

Distinguishing PBL from free-tropospheric CO for determining long-range transport of pollution and emission sources

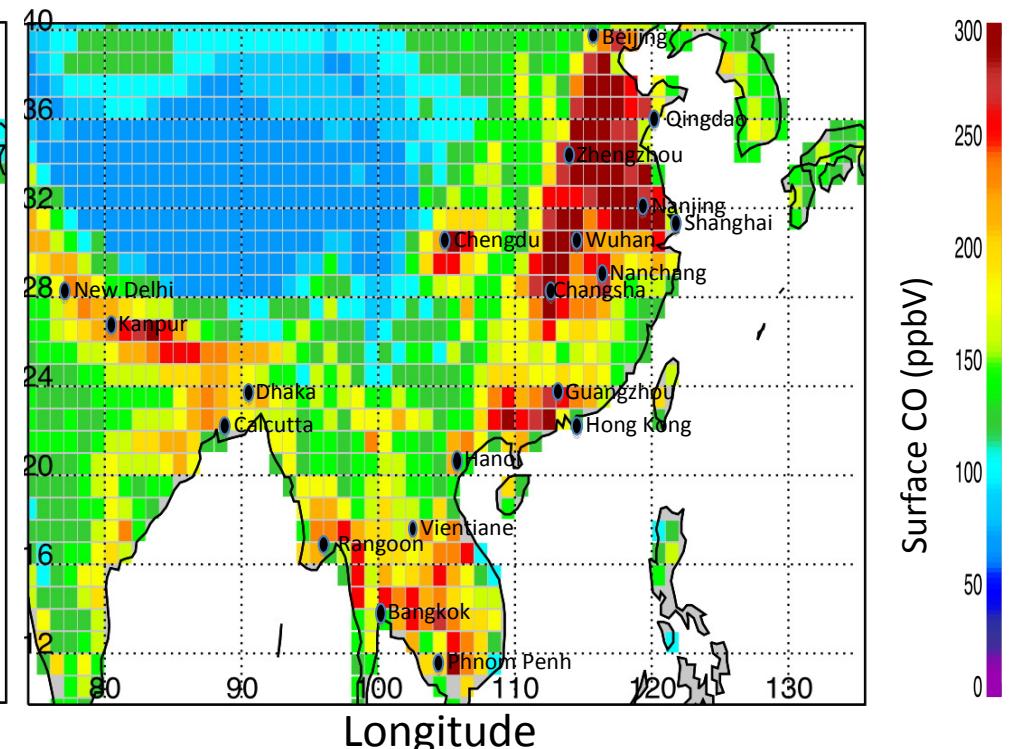
# Combined CO Retrieval



TIR-only



TIR+NIR



MOPITT retrievals over central/east Asia with single a priori

2005-2008 average for Sep/Oct/Nov

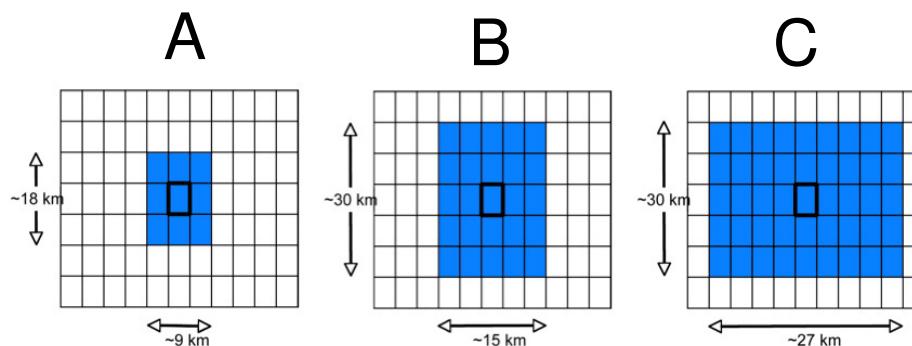
Worden et al., JGR-Atmos. In press (accepted May 2010)

# Cloud Clearing



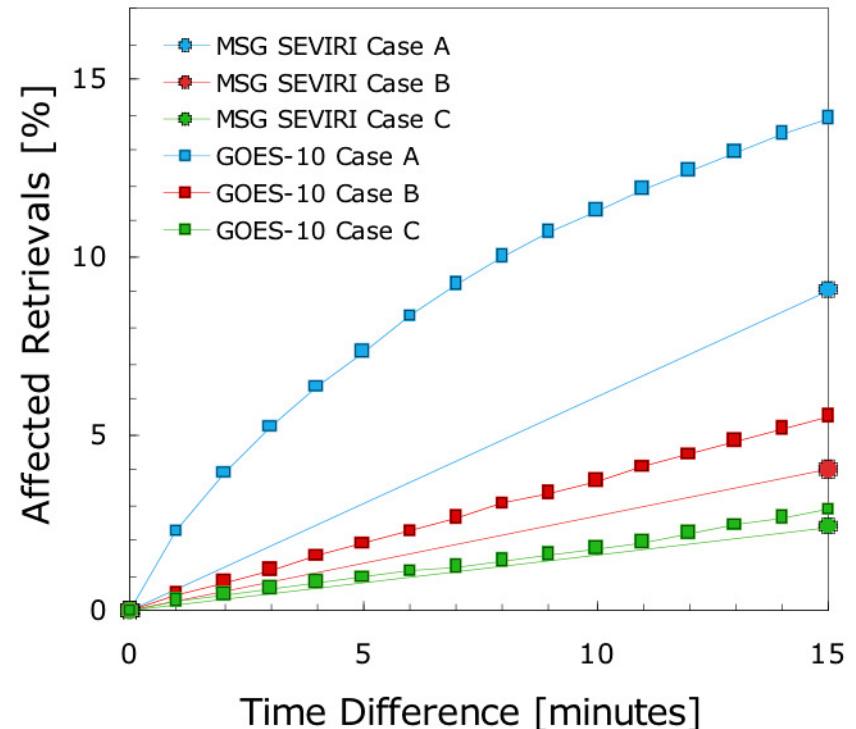
**To use imager data for cloud-clearing S-5 data the time difference should be less than 1-7 min, depending on cloud-cleared area.**

(Genkova, Veefkind et al., submitted to AMTD)



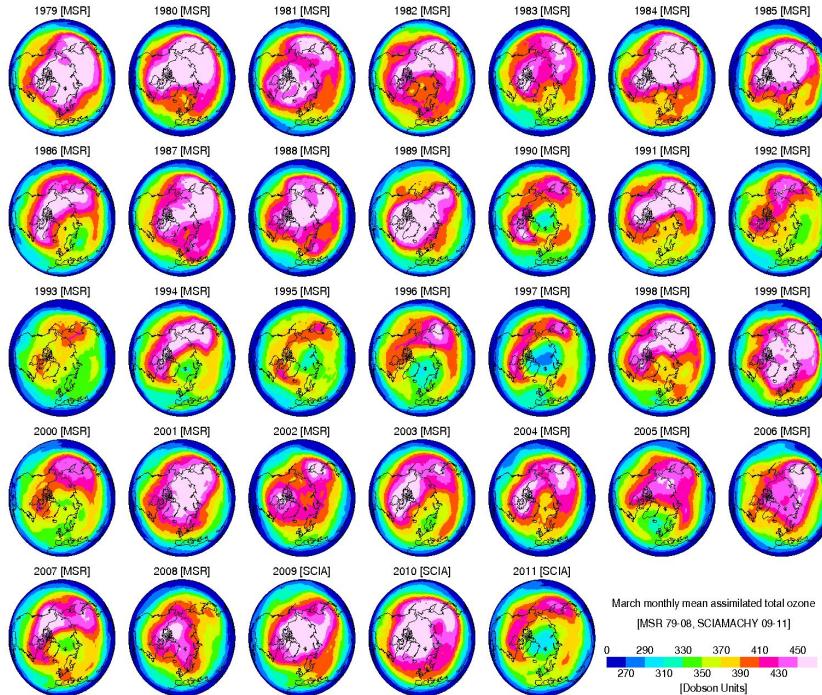
Cases studied: A) cloud cleared region 18x9 km<sup>2</sup>, B) 30x15 km<sup>2</sup>, C) 30x27 km<sup>2</sup>. Center pixel coincides with the target S-5 pixel.

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Data sets: **MSG SEVIRI** cloud mask with 15 min interval for 2006 over Europe, **GOES-10** 1 minute interval data for 23 August 2006 over the South U.S.A.

# Sentinel 5's synergy with IRS, VII and 3MI essential for next step in European atmospheric monitoring and research



Multi Sensor Re-analysis (MSR):  
30 year of assimilated ozone  
based on bias-corrected satellite  
data, Van der A et al, KNMI

Crucial for monitoring and science:

- Understanding climate chemistry interaction
- Accurate Emission monitoring
- Secondary aerosol formation
- Continuation of European Ozone layer monitoring

Key is synergy instruments on Platform A:

- Colocated and co-timed trace gas and aerosol measurements (same air mass)
- Combined retrieval s5 and IRS
- Co-located Cloud imager
- Co-located 3MI instrument

- Sentinel 4, 5 and s5p will deliver a wealth of information to study the tropospheric composition, air quality and climate change.